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The Ecology of Rodents in the Tonga Islands[1]

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THE INFLUENCE on crop damage of *Rattus norvegicus*, *Rattus rattus*, and the native Polynesian rat, *Rattus exulans*, was studied during the establishment of a rat control program for the Tongan Department of Agriculture in 1969. This was the first long-term study of Tongan rodents. Previous scientific literature on Tongan mammals is very sparse. The Kingdom of Tonga, or Friendly Islands, consists of approximately 150 small islands with a combined area of about 256 square miles at lat 21° S. The majority of these islands are composed of raised coral limestone; however, there is a row of six volcanic islands on Tonga's western border. Tongatapu, the location of the government center, is the largest and most important island. The Ha'apai island group lies 80 miles north of Tongatapu, and 150 miles north is the Vava'u group. Fiji is 420 nautical miles east and Samoa is 480 miles north. The climate is tropical and is influenced seasonally by trade winds.

Concerning the people, T. F. Kennedy (1958) says: "Polynesians, ranging southwards from Samoa, first settled in Tonga in about 500 A.D. They found a widely-scattered group of high volcanic and low raised-coral islands. They established themselves, not only on the main islands, but also on many of the smaller islands, which, although now uninhabited, show evidence of past settlement, probably on a family-unit basis." Some students of Pacific prehistory put the date of arrival of Polynesians in Tonga much earlier, and suggest that they came to Tonga from Fiji. These details are not important to this paper; Polynesians have been traversing the central Pacific for many centuries, and during this period doubtless transported the Polynesian rat to many islands in their voyaging canoes. (See Tate, 1935.)

Since Captain Cook's first visit in 1773, Western civilization has brought trade, missionaries, and perhaps rats to Tonga. With this shipping came numerous introduced plants and animals. The arrival dates for the common rat, *Rattus norvegicus*, and the "European" roof rat, *Rattus rattus*, are not known, but are believed to be more recent, probably since the increase of regular shipping trade and the construction of wharves.

Presently rodents account for approximately 20 percent of the agricultural losses and $50,000 worth of economic loss each year (Twibell, unpublished). This is a conservative estimate based on damage counts and observation. In some areas rats destroy or damage up to 50 percent of the coconuts, which represent the main economic crop in Tonga.

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METHODS

From January to December, 1969, rodents were obtained by snap traps and livetraps set adjacent to and in agricultural areas to determine densities, habitat preference, food habits, and related crop damage. Various means of rodent control were also tested; anticoagulant poisons were the principal control methods employed.

External measurements were taken according to the British system of measuring tip of nose to anus for body length and from anus to tip of tail integument for tail length. These combined measurements were used in Table 1.

Some rats were maintained alive in captivity for tests of food preference, behavior, and general observation.

Five islands were trapped to give an indication of the species distribution present (Table 2

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TABLE 1

TOTAL LENGTH OF ADULT *Rattus exulans* FROM MID-PACIFIC ISLANDS

LOCATION	$\bar{X}$ BODY LENGTH (mm)	S	2 SE	N
Kure Atoll, Hawaii (W. O. Wirtz, 1972)	292	–	–	80
Ponape, Micronesia (D. H. Johnson, 1962)	282	16.1	±6.82	22
Upolu, Western Samoa (R. R. Marples, 1955)	259	15.8	±4.84	42
Tongatapu, Tonga (Present study, 1969)	241.2	18.3	±6.9	28

TABLE 2

RELATIVE ABUNDANCE OF SPECIES TRAPPED ON FIVE TONGAN ISLANDS

LOCATION	*Rattus norvegicus* (%)	*Rattus rattus* (%)	*Rattus exulans* (%)	NUMBER
Tongatapu	56	5.5	38.5	55
'Eua	–	29	71	14
Vava'u	21	11	68	28
Niuatoputapu	–	–	100	29
Hunga	12.5	50	37.5	8
Total				134

and Fig. 1). No individuals of *Mus musculus* were caught, observed, or reported to have been caught, contrary to other reports (Carter, Hill, and Tate, 1945). The five islands trapped differ in relation to geological makeup, size, trade contact, agricultural methods employed, and composition of the *Rattus* population.

RESULTS

Tongatapu

Tongatapu was the most intensively studied island because it is the largest and most productive agriculturally and has the best facilities for transportation. Government offices are in the capital city, Nuku'alofa. Tongatapu is a flat, uplifted, coral island, with a maximum height of 270 feet. The topsoil is composed of 2 or 3 feet of volcanic clay. Approximately 60 percent of the 100-square-mile land area is devoted to raising coconuts and bananas for export. The agricultural methods are the most advanced in the kingdom. Some fertilizers and limited farm machinery are used.

All three species of *Rattus* are present. R. *norvegicus* damages approximately 30 percent of such ground crops as sweet potatoes, peanuts, watermelon, and corn (Fig. 2). R. *rattus* is the sole cause of coconut damage, which amounted to a 20-percent loss during the study. R. *exulans* also contributed to ground crop damage to tapioca, sweet potatoes, peanuts, and corn. On Tongatapu the Norway rat is present near agricultural areas whereas the Polynesian rat is more frequently found in native tropical bush. Jackson and Strecker (1962) found a similar pattern of distribution in Micronesia.

Trapping of the same area in 1965 yielded 65 percent R. *exulans* and 25 percent R. *norvegicus* (Bianchi and Smythe, 1965). In contrast, my trapping showed Norway rats to be more abundant (Table 2), suggesting that the Polynesian rat is possibly being forced out of the agricultural habitat into the native bush areas. Modern

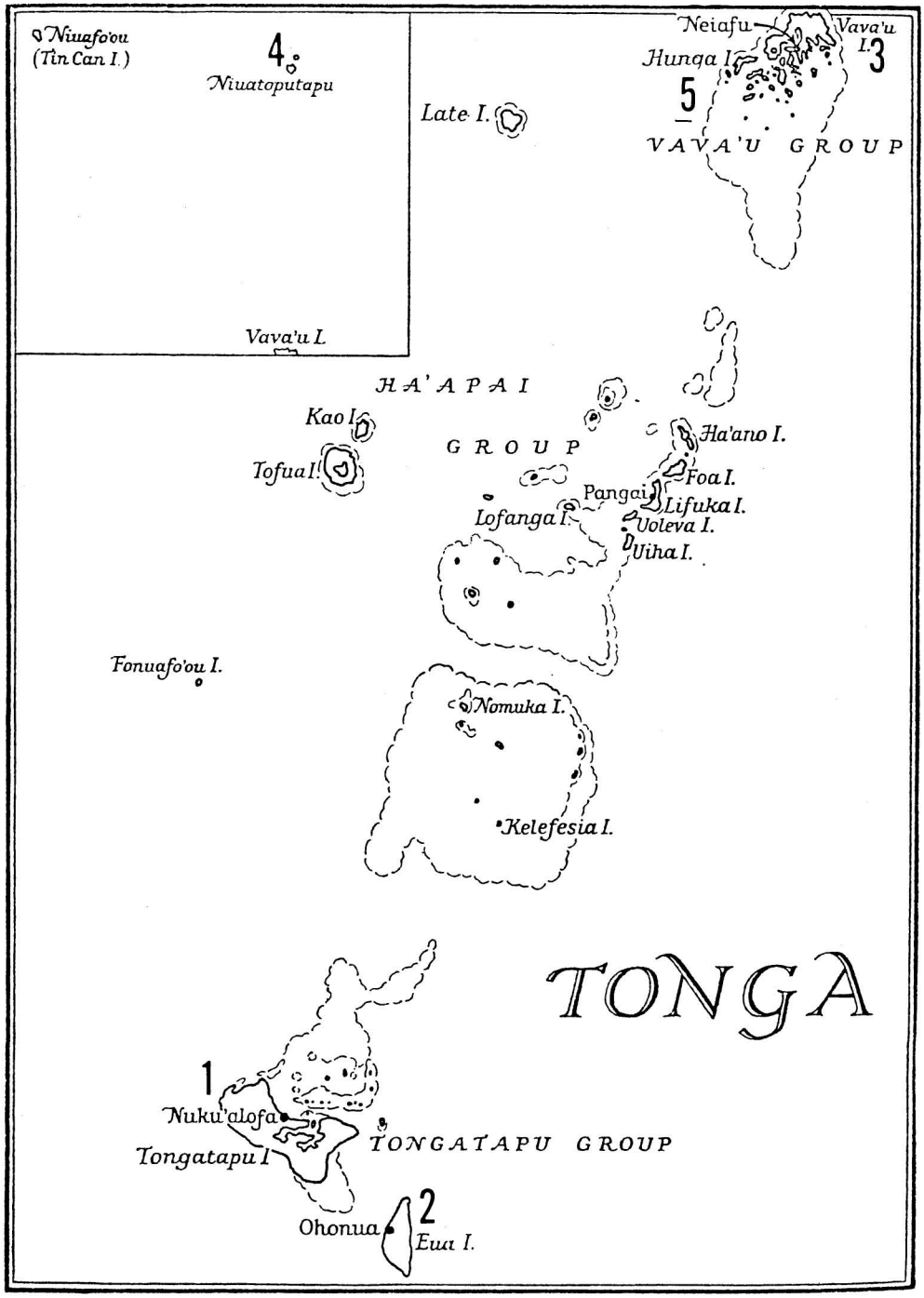

FIG. 1. Map of Tonga. Numbers indicate sampling areas.

FIG. 2. Corn damaged by Norway rats (*Rattus norvegicus*).

agricultural practices seem to favor R. *norvegicus*.

On two occasions I observed that, when members of the same sex of R. *norvegicus* and R. *exulans* were put together in an observation cage, the Polynesian rats were killed by the larger and more aggressive Norway rats within 30 seconds. These data suggest that R. *norvegicus* is the more aggressive species, which characteristic may result in an increase in its numbers on the island.

'Eua

'Eua is a relatively pristine and mountainous island. Its maximum elevation is 1,078 feet and its area is 33.7 square miles. Approximately 20 percent of the land area is used for agriculture. The absence of Norway rats on 'Eua (Table 2) may be due to the limited trade (a daily launch) and lack of agricultural areas. Coconut damage by individuals of R. *rattus* is approximately 20 percent here also. Apparently R. *exulans* thrives well on guava fruit, which is abundant among the coconut groves. No specific food studies were made to demonstrate this; however observation has verified it.

Vava'u

Vava'u (the name of the main island is 'Uta Vava'u) is the second largest island in the kingdom, 34.6 square miles. It is about 165 nautical or 187 statute miles north of Tongatapu, and like Tongatapu it is composed of raised coral limestone, with a rich topsoil, and a maximum height of 670 feet on its western coast. Vava'u is the second-best copra-producing area in the Tonga Islands. Approximately 30 percent of the tillable land is used at one time. The other good soil is allowed to lie fallow for 4 to 6 years to regenerate itself.

All three species of *Rattus* were present here, but R. *exulans* dominates in relative abundance

FIG. 3. Coconuts damaged by roof rats (*Rattus rattus*).

(see Table 2), which is unlike the situation in Tongatapu. This could be due to several factors: (1) the Norway rat has not been in Vava'u as long as it has been in Tongatapu, (2) the environment is not well suited to *R. norvegicus* because it is less developed agriculturally, or (3) *R. norvegicus* exhibits different behavior on this island.

Hunga

Hunga is an outlying island near 'Uta Vava'u, in the Vava'u group, with an area of about 1.85 square miles and a maximum elevation of 245 feet. It is visited only by local launches. Primitive agriculture is practiced here. There are no motor-driven vehicles or advanced farming techniques on the island. Copra sold for export is the only source of livelihood for the people but, unfortunately, the *R. rattus* population seems to be most abundant in this crop. Coconut loss due to rats is assessed at between 50 percent and 70 percent (see Fig. 3). This is similar to Smith's observations (1968) in the Gilbert Islands.

Niuatoputapu

Niuatoputapu (also called Keppel's Island) is one of the most isolated islands in the kingdom. Except for neighboring Tafahi, which is a rugged volcanic peak 2,000 feet high with an area of 1.3 square miles, it is 50 miles from any other island. It is visited by a government ship about once a month, but has no wharf other than one which will accommodate launches. It is a volcanic island with an area of 5.7 square miles, fertile lowlands surrounding a 350-foot peak.

Only *R. exulans* was found on Niuatoputapu,

but it was found in large numbers. Trapping results in August 1969 indicated about 40 rats per acre. No coconut damage was observed and no rats were caught in coconut palms. This was quite different from conditions found in the Tokelau Islands, 300 nautical or 340 statute miles north of Samoa (Wodzicki, 1968). On Niuatoputapu only slight agricultural damage was evident on some root crops such as the giant taro and sweet potato. One-hundred-percent damage is common for corn crops.

DISCUSSION

Compiled data provide evidence to compare the body size of R. *exulans* (see Table 1). Its mean body length of 241.2 millimeters from Tongatapu is significantly smaller than on other central Pacific islands. Tate (1935) suggested that the Tongan R. *exulans* is derived from more northerly populations. Although Tate referred to the homogeneity of R. *exulans* from different islands, the evidence presented here demonstrates that identifiable strains have evolved.

Predators are rare on the islands, except for one species of owls and feral cats (Baker, 1946). The major determinants of rat population size seem to be available habitat and food.

A general habitat preference was observed for each species:

1. R. *rattus* occasionally lives on the jungle floor, but it is usually trapped on the trunks or in the crowns of coconut palms. This rat typically gnaws a hole in green coconuts and proceeds to drink the milk and eat the meaty material adhering to the edges of the shell (Fall, Medina, and Jackson, 1971). Nests with young frequently are found inside large coconut shells. Of all three species of rats released alive on the surface of coconut tree trunks, only R. *rattus* attempted and was successful in climbing to the tops of the crown. This is a further indication that roof rats are most suited for living in treetops.
2. R. *norvegicus* lives in burrows associated with agricultural crops, among tree roots, and around tall grasses such as *Ischaemum*. If suitable habitat for nesting in agricultural areas is not available, it will move to places adjacent to fields and subsist on native fruits, seeds, roots, and insects.
3. R. *exulans* appears best suited to habitats of native plants. The sensitive plant (*Mimosa pudica*) produces an abundant amount of seeds that are palatable to them. The Polynesian rat is a ground dweller in Tonga; it frequently builds subterranean nests near or under *Ischaemum* grass. Therefore, R. *exulans* and R. *norvegicus* may be in competition for the same habitat.

SUMMARY

The three species of *Rattus* are apparently distributed according to time of arrival in the islands, habitat preference, agricultural conditions, and possibly competitive relationships. Islands with more trade and advanced agricultural techniques are likely to have roof rats and Norway rats. Both of these rats cause economic losses and are potential disease carriers. The more widely spread indigenous species, R. *exulans*, remains relatively unimportant economically and is found in native habitat and root crops where R. *norvegicus* is not present. R. *norvegicus* dominates grassland and agricultural areas whereas R. *rattus* is usually found near its preferred coconut trees for climbing and nesting.

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